Insulated Weather-Resistant Interlocking Roof System and Method

Technical Field

The present invention relates generally to interlocking, pre-fabricated structural panel systems and, more particularly, to a system of insulated, weather-resistant interlocking roof panels and associated methods of use and manufacture.

Background of the Invention

In roof construction, particularly of the type associated with large commercial or industrial buildings, conventional roofing systems involve at least three distinct steps. First, a steel erector will install a metal deck which is welded down or screwed down to structural members such as bar joists or purlins. A roofing contractor will then install an insulation layer, which typically comprises a three-inch layer of polyurethane. In the final step, the roofing contractor will install a weather-resistant, corrosion-resistant membrane over the insulation layer in order to seal the roof assembly.

Construction time and costs, and structural weight, can be considerably reduced by eliminating one or more of the above-mentioned steps. Various designs exist for modular, pre-fabricated roofing panels that eliminate the separate steps of installing a metal roof deck and installing an insulation layer. One such design is disclosed in U.S. Patent No. 5 277 011, in which pre-fabricated roofing panels comprising metal outer skins and an insulating filler material are directly secured to transverse purlins, thereby eliminating the need for a separate base deck and associated procedural steps. The roofing panels require, however, weather strips or sealing joints, as well as water-drainage channels.

Another type of roofing panel is disclosed in U.S. Patent No. 4 575 981. The panel, which is designed for use in an inclined roof, comprises a metal outer sheet over a foam or plastic core and has on one side a male or female component, respectively, of a ship-lapped joint designed for interlocking. The ship-lapped joint requires the use of a sealant rod or caulk strip for forming a water-tight seal and is designed for uni-directional

primary sealing and, thus, is suitable only for inclined roofs in which the joints are uni-directionally aligned.

U.S. Patent No. 5 394 672 discloses a roof panel system in which panels comprise outer metal sheets surrounding an insulation core and having alternate mating edges for interlocking adjacently placed panels. The panels disclosed in this patent, as well as those described in U.S. Patent No. 4 578 981 and U.S. Patent No. 5 277 011, are not provided with pre-applied corrosion-resistant membranes. The panels described in U.S. Patent No. 5 394 672 require an additional step of applying a water-resistant polymeric paint after the roof is assembled.

U.S. Patent No. 4 706 435 describes a roof panel comprising a fiber board panel having a factory-installed, bitumenized waterproof membrane. The membrane is arranged to provide one head-lap and one side-lap so that lap joints can be achieved between adjacently placed panels. The laps, however, require the additional step of spot-mopping hot asphalt or adhesive along the side-lap or head-lap during installation. The panels are designed to be installed on a substrate or pre-existing deck and are not capable of forming, by themselves, a structurally sufficient roof.

Objects of the Invention

It is an object of the present invention to provide a roofing system comprising pre-fabricated roofing panels of a design that affords structural strength, that eliminates the need for a roof sub-deck, that provides superior insulation and corrosion-resistance, and that significantly simplifies manufacturing and assembly methods and reduces associated costs. By eliminating the need for a sub-deck and additional sealing materials, overall weight and cost of materials are reduced. Simplification of roof assembly reduces labor costs and assembly time.

It is another object of the invention to provide a method of manufacturing such panels in which an outer, protective layer is applied to the panels in a continuous process

so that the panels can be shipped to a job site with the protective layer pre-installed allowing for one-step roof assembly and sealing.

These and other objects of the invention are inherently disclosed in the description that follows.

Summary of the Invention

A preferred embodiment of the present invention is directed to a roofing system comprising individual roofing panels that include a metal outer skin surrounding an insulation layer, a factory-applied protective membrane, and interlocking components for providing a rigid roof that is self-supporting and requires no sub-deck. The panels with pre-applied protective membranes are adapted to be factory-shipped to a job site so that assembly and sealing can be achieved in a one-step process. In the preferred embodiment, upper and lower steel skins are rolled out and maintained at a desired distance while foam insulation is injected therebetween. A corrosion-resistant membrane of polyisobutylene is rolled out and applied to the outer surface of the upper steel skin using a spray adhesive. Along the longitudinal edges are mating configurations designed to interlock adjacently placed, like panels. Reinforcing strips and screw holes are provided for enhanced strength and fastening capabilities.

Brief Description of the Drawings

Fig. 1A is a schematic, perspective view of a panel according to a preferred embodiment of the invention.

Fig. 1B is a schematic, cross-sectional end view of the panel of Fig. 1A taken along line 1-I.

Fig. 2A is a schematic, cross-sectional, partial end view of two panels of the type shown in Fig. 1B adjacently positioned and interlocked according to the present invention.

Fig. 2B is a schematic, perspective view of two panels of the type shown in Fig. 1A adjacently positioned, interlocked and mounted to structural members according to the present invention.

Fig. 3 is a schematic, partial cross-sectional side view of two panels of the type shown in Fig. 1A placed end-to-end and mounted to a structural member according to the present invention.

Fig.s 4A-4B are schematic diagrams of a manufacturing system and method for making a panel of the type shown in Fig. 1A according to the present invention.

Description of the Preferred Embodiments

A building panel (110) according to a preferred embodiment of the present invention is shown in Fig.s 1A and 1B. The panel (110), while presented herein for use as a roof panel, may be utilized for other purposes in which similar or analogous environmental and structural conditions exist. The panel (110) includes an upper membrane (112), a lower membrane (114), an interior section (116), and a protective outer membrane (118).

The upper and lower membranes (112, 114) are made from steel sheets and may be made from other suitable metallic or non-metallic materials having similar properties. In the preferred embodiment, 22 - 26 gauge steel is used for the membranes (112, 114).

The interior section (116) serves primarily as an insulation layer. Depending on the desired use, the interior section may be enhanced for additional purposes such as fire-resistance or strength enhancement. In the preferred embodiment, the interior section (116) is comprised of a three-inch layer of polyurethane foam. If desired, the interior section (116) may comprise multiple layers of different materials having various characteristics suitable for the panel's intended use.

The outer membrane (118), which is designed to withstand the corrosive effects of weathering, is comprised of a membrane of polyisobutylene (PIB), such as that available in single-ply sheets from Republic Powdered Metals, Inc. and sold under the mark "GEOFLEX HD." The outer membrane (118) is adhered to the upper membrane (114).

Referring to the cross-sectional view of Fig 1B of the panel (110), the upper and lower membranes (112, 114) are arranged generally in parallel relationship. They are off-

set vertically and horizontally to accommodate the angled side walls (120, 122) of the interior section (116) which, as described below, are configured to provide lock-fitted mating between adjacent panels.

As shown in Fig 1B, the outer membrane (118) is provided with a side-lap portion (124) that extends beyond a lateral edge of the panel (110). The side-lap (124) may extend any suitable distance to form a watertight, weatherproof seal between adjacently engaged panels, as described in more detail below. In the preferred embodiment, the side-lap extends approximately 4 inches. An end-lap (126) may be provided on a first end (142) of the panel (110) to provide a watertight seal between adjacent panels placed end-to-end. The underside (125) of the lap portions (124, 126) is provided with a peel-away sheet (127) having adhesive (129) underlying which, when peeled away, facilitates adhesion of the laps (124, 126) to adjacently placed panels (110).

A first side wall (120) extends downwardly from a first edge of the upper membrane (112) at an angle ß to the edge of the upper membrane (112). In the preferred embodiment, the angle ß is approximately 45° though this angle may be varied. A first male connecting member (130) extends outwardly from the first sidewall (120) in a horizontal direction. A first female connecting member (132) is positioned below the male member (130) and extends inwardly from the first sidewall (120) in a horizontal direction.

Opposite the first sidewall (120) is a generally parallel second sidewall (122) that extends between the upper and lower membranes (112, 114), The second sidewall (122) has second male and female connectors (136, 138) that are positioned opposite the first male and female connectors (130, 132) with respect to vertical position in order to align in mating relationship when like panels (110) are engaged adjacently, as shown in Fig. 2A. Reinforcing members (140, 142) are provided in the form of steel, elongated strips that add strength reinforcement to the connectors (132, 138). Additional reinforcing members may be provided to remaining connectors or other sections of the panels.

As shown in Fig.s 2A-2B, the panels (110) are assembled adjacently such that they each span, in a longitudinal direction, consecutive structural members (144, 146) such as

joists or purlins. For each distance L between consecutive structural members (144, 146) each panel (110) should be at least L in length.

Referring to Fig.s 2A and 2B, each panel (110) may be provided with a first screw hole (148) adapted to receive a screw (152) for securing the panel (110) directly to a flange (154) of a structural member (144). Each panel (110) also may include second and third screw holes (156, 158) through male and female connectors (136, 132). The holes (156, 158) line up, respectively, when adjacent panels (110) are engaged as shown in Fig 2A, providing a passage for a second screw (160) which locks adjacent panels (110) to each other and, if desired, to the flange (154) of the structural member (144),

Each panel (110) may be selected to be of a length suitable for its purpose without the need to be placed end-to-end with another panel (110). Alternatively, the panels (110) can be placed end-to-end in addition to being placed adjacently side-by-side as described with respect to Fig.s 2A-2B. For example, as shown in Fig.3, panels (110) placed end-to-end may be positioned so that a first end (162), having an end-lap (163) as shown in Fig. 1A, can be placed next to another panel's second end (164) having no lap. The connection can be positioned directly above a structural member (166) thereby providing support and a surface (168) for securing a plurality of screws (170) to hold the panels (110) to the structural member (166).

Because the panels (110) are factory-shipped with the outer membrane (118) pre-applied and adapted to form sealed joints, the assembly and sealing of a roof section using the panels (110) is achieved in one step.

The panels (110) according to the present invention are manufactured according to a preferred method described herein. Referring to Fig.4, a schematic representation depicts first and second steel membrane rolls (200, 202) of pre-selected widths corresponding to a predetermined panel width. The rolls (200, 202) have associated drivers (204,206) of the type generally known in the art. One or more contollers (208) of the type known in the art may be associated with each driver to control various functions. The drivers (204, 206) are activated to selectively unroll the steel membranes (210, 212)

which form the upper and lower membranes (112,114) of the finished panels (110) according to the present invention. Tension rollers (214) or similar means are employed to maintain the membranes (210, 212) at a constant distance to hold them generally parallel to each other as they are unrolled.

The reinforcing members (140,142) may be formed by bending a lateral edge of the steel membranes (210, 212) or by welding or otherwise fastening the reinforcing members (140, 142) to the steel membranes (210, 212). In the preferred embodiment, the reinforcing members (140, 142) are conveyor-fed from rolls (141, 143) in synchronization with the feeding of the steel membrane rolls (200, 202). The reinforcing members may be held in position by injected foam, as described below, or adhered, by conventional means, directly to the steel members (210, 212). As the steel membrane rolls (200, 202) unroll the steel membrane (212, 214), an injection device (216), or plurality thereof of a conventional type, injects polyurethane foam between the steel membranes (212, 214) to form the interior section (116) of the panel (110). Conventional molding plates (213,215) or similar means as are known in the relevant art are selectively positioned during injection of the foam to shape the angled sidewalls with male and female connectors as described above, or additional features. A final step of applying the outer membrane (118) to the upper membrane (114) is carried out after cutting off the panels (110) to desired lengths. A conventional cutter (217) cuts off the panel (110) at a desired length.

Referring to Fig.4, panels (110), having been cut but not yet having the outer membrane applied are conveyed past a first limit switch (230). The first limit switch (230) is tripped to activate a first air cylinder (232). The first air cylinder (232) moves two side rollers (234, 236) into engagement with the panels (110) to bias the panels (110) against oppositely mounted idler rollers (238, 240) to align the panels (110). The side rollers (234, 236) are driven by a variable speed motor system (242, 244) which advances the panels (110) along at a speed in the range of one to sixty feet per minute in a direction represented by the arrow (231) shown in Fig.s 4A-4B.

As each panel (110) advances, it trips a second limit switch (246) which activates two spray guns (248, 250) that spray caulk on each side of the panel (110) into the female connectors (132, 138) to enhance fit and sealing between adjacently mated panels (110).

Referring to Fig.s 4A-4B, each panel (110) will continue to move along until it trips a third limit switch (252). The third limit switch (252) activates adhesive spray guns (254, 256) which spray adhesive onto the upper membrane (114).

Each panel (110), with adhesive applied, advances while the PIB membrane (217) is unrolled and applied to the adhesive-treated area of the panel (110). In applying the outer membrane (118), comprising a PIB membrane, the outer membrane material is provided in as large a roll (217) as possible for optimal production efficiency. The PIB roll (217) is mounted to a roller driver assembly (218) of the type generally known. The PIB roll (217) is positioned and introduced from above the production line for the panels (110) after they have been cut. By positioning and running the PIB roll (217) above the panel production line, selective positioning of the PIB roll for proper alignment relative to the panels to be formed is achieved. As the PIB membrane (217) is unrolled it travels through a conventional pinch roll system (220), down a slide (222) and under a pressure roller (224). When one PIB roll (217) runs out of material, an operator will bond the end of the material with that of a new roll to maintain continuity in the operation. One or more rollers such as pressure roller (258) presses the PIB membrane (217) against the panel upper membrane (114) thereby causing adhesion therebetween. The pressure roller (258) can be mounted to an air cylinder (260) or other conventional means to activate the pressure roller (258) in response to tripping of a fourth limit switch (262) by the advancing panel (110). The fourth limit switch (262) also activates a flying cutter (266) of a conventional type that cuts the PIB membrane (217) at both leading and trailing ends. In the preferred embodiment, the end lap (163) is formed at the trailing end. By adjusting the fourth limit switch (262), the length of the end-lap (163) can be varied. In the preferred embodiment, the end-lap (163) extends 1 to 4 inches. Similarly, as the trailing end (264) of each panel (110) passes each of the limit switches described above, each associated

operation is stopped as re-set for the next passing panel. The side rollers (234, 236) will continue to run thereby advancing each panel (110) on to further operations such as stacking, banding and shipping.

While the preferred embodiments of the present invention have been herein describd, it is understood and acknowledged that various modifications can be made without departing from the scope of the present invention. For example, the novel method described and claimed herein for factory-applying an outer sealing membrane to a pre-fabricated roof panel may be carried out with panels that vary from the precise configuration described above with respect to the preferred embodiment. Similarly, the novel method described and claimed herein for assembling and sealing a roof system in a single process step may be carried out with panels that vary from the precise configuration described above with respect to the preferred embodiment.